A HANDWRITING PEN CAPABLE OF SIMULATING DIFFERENT STROKES

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a handwriting pen and more particularly relates to a handwriting pen capable of simulating different pen strokes.

Description of the Prior Art

Recently, handwriting entry devices emerge to form a new generation of input devices. In general, a handwriting device comprises a handwriting tablet and a handwriting pen, supports user handwriting with a stylus directly on the tablet, and features an alternative means to replace the keyboard mode of input. Popularly seen handwriting devices are categorized into the following two types: Tablet PC, consisting of a flat-screen LCD panel and an electromagnetic sensitive touch-control pen; and WACOM digitizer or graphics tablet, consisting of a pressure sensitive graphics tablet or digitizing tablet, and a pressure sensitive pen. Moreover, the users have to install recognition software; for instance, Photoshop and the like graphics software in the computer system, for the recognition of what the users write or draw by means of the

handwriting entry devices.

The recognition software has to recognize a position that the handwriting pen taps on the handwriting tablet, an (X, Y) coordinates; and pressing force with the handwriting done by an individual user, a pressure value Z, to simulate pen strokes of distinct styles. However, due to the deficiency in acquiring enough data, the existing graphics software; for instance, Photoshop, CorelDraw, Painter, etc, have tremendous deficiency in the simulation of the pen strokes.

SUMMARY OF THE INVENTION

Therefore, the main purpose of the present invention is to offer a handwriting pen an attribute of simulating different pen strokes, to accomplish the simulation of distinct styles of individual pen strokes according to the distinguishing feature of the hand press, and to further enhance the power of simulating the pen strokes by the graphics software.

The handwriting pen of the present invention comprises a pen tip; a pen tip position recognizer, capturing a main position coordinates of the pen tip on the handwriting tablet to generate a main position data; a pressure generator, sensing a value of pressure exerting by the pen tip on the handwriting tablet panel to generate a pressure value. The handwriting pen connects to main system by a signal transmission line

through which the main position data and the corresponding pressure value are sent to the main system. The main system has a pen stroke simulation apparatus, which manipulates the main position data and the pressure value, and simulates the pen strokes of distinct styles. The pen stroke simulation apparatus comprises a pressure-radius transformation module, which receives the pressure value, and converts it into a radius data; a positive vector generation module, receiving the main position data through which a positive vector data is generated; a density location generation module, connecting to the pressure-radius transformation module and the positive vector generation module, for generating a plurality of density locations to represent a plurality of density location coordinates in the direction of the positive vector at the main positions, according to the radius and the positive vector data; and a pen stroke generation module, drawing a main line of trajectory according to the pen tip sliding across the main positions over time, and drawing a plurality of density lines according to the density location data, wherein each main position data corresponds to a plurality of the density location data.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention featuring its novelty, can be readily understood by reading the following detailed description of the preferred embodiments, with

reference made to the accompanying drawings, wherein:

Fig. 1 shows a handwriting pen accompanying a handwriting tablet in the usage of the present invention;

Fig. 2 shows a relationship between radiuses of circles and pressure values;

Fig. 3 is a schematic diagram of the present invention showing the handwriting pen connecting to a main system;

Fig. 4 shows a plurality of density location coordinates;

Fig. 5 shows a main line and density lines;

Fig. 6 is a flow diagram showing a pen stroke forming method of a pen stroke generation module;

Fig. 7 is a schematic diagram showing a pen stroke formed by the pen stroke generation module;

Fig. 8 is a block diagram of the pen stroke generation module;

Fig. 9 shows dispersion position coordinates;

Fig. 10 is a schematic diagram of different pen strokes;

Fig. 11 is a schematic diagram of the handwriting pen of the present invention;

Fig. 12 is a system structure diagram of the handwriting pen;

Fig. 13 is a schematic diagram of the handwriting pen undergoing a deformation at its pen head;

Fig. 14 is a schematic diagram of a gear and a rotation velocity detector of the handwriting pen

Fig. 15 is a circuit block diagram of the handwriting pen;

Fig. 16 shows a bending angle of a pen head;

Fig. 17 shows a variation relationship between the bending angle of the pen head and the pressure value by the handwriting pen; and

Fig. 18 is a schematic diagram of another example of the handwriting pen of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Please refer to Fig. 1. Fig. 1 is an exterior view of the present invention, showing the usage of a handwriting pen 10 (detail structure will be described in the next paragraph) and an accompanying handwriting tablet 12. As shown in the figure, the handwriting pen 10 comprises a pen tip 11, where a user employs the handwriting pen 10 writing on the handwriting tablet 12 to accomplish a pen stroke 14 which is composed of a plurality of circles 16, where the center of the circle 16 is represented by O and the radius ϖ.

Please refer to Fig. 2. Fig. 2 shows a relationship between the radius ϖ of circle 16 and pressure value Z. As shown in the figure, the harder the user presses down on the pen tip, the larger the pressure value Z of the handwriting pen 10 is, and hence the radius ϖ of the circle 16 becomes lengthy. In other words, according to a variety of pressure values Z, the handwriting pen 10 over time generates a lot of circles

16 varied in size on the handwriting tablet to form the pen stroke 14, where Maxϖ is a preset maximum value of radius.

Please refer to Fig. 3. Fig. 3 is a schematic diagram of the present invention showing the handwriting pen 10 connecting to a main system 21. The handwriting pen 10 comprises a pen tip position sensor 18 and a pressure sensor 20. The pen tip position sensor 18 is used to capture a main position coordinates O_i, where the pen tip 11 taps on the handwriting tablet 12, for generating a main position data. The main position coordinates O_i is the center of the circle 16 that the handwriting pen 10 generates over time t_i, which can be denoted as a coordinates (X_i, Y_i). The pressure sensor 20 is used to sense the pressure that the pen tip 11 presses down on the handwriting tablet 12 to form a pressure value Z.

The handwriting pen 10 connects to the main system 21 by a signal transmission line (not shown) through which the main position data and corresponding pressure values are sent to the main system 21. The main system has a pen stroke simulation apparatus 23; for instance, graphics software or recognition software that manipulates the main position data and the pressure values, for simulating different pen strokes.

The pen stroke simulation apparatus 23 comprises a pressure - radius transformation module 22, a positive vector generation module 24, a density location

generation module 26, and a pen stroke generation module 28. The pressure-radius transformation module 22 is used to acquire a pressure value Z, and through applying a pressure-radius transformation equation, the pressure value Z is thus transformed to a radius value ϖ. The pressure-radius transformation equation is established by the relationship between the radius ϖ and the pressure value Z in Fig. 2, and represented as:

$$\begin{cases} \varpi = f(z) = (Max\varpi) * \left(\dfrac{e^{z} - 1}{e - 1} \right) \\ where \\ f(0) = 0 \\ f(1) = Max\varpi \\ 0 \le Z \le 1 \end{cases}$$

The positive vector generation module 24 is used to acquire the main position data through which a positive vector data is generated. The positive vector generation module 24 first acquires an instantaneous direction of the pen tip 11 at the main position coordinate O_i, according to the main position data, and the equation is expressed as:

$$V_i = \frac{O_i - O_{i-1}}{|O_i - O_{i-1}|} \quad ;$$

where V_i represents the instantaneous direction of the pen tip 11 over time t_i; O_i, the main position coordinates of the pen tip 11 over time t_i; and O_{i-1}, the main position coordinates of the pen tip 11 over time t_{i-1}. Suppose V_i = (x, y), the positive vector data N_i = (-y, x).

The density location generation module 26, connects to the pressure-radius transformation module 22 and the positive vector generation module 24, employs the radius data ϖ and the positive vector data N_i to generate a plurality of density location data, in the direction of the positive vector over the main position coordinate O_i, and represents a plurality of density location coordinates b_{ij}.

Please refer to Fig. 4. Fig. 4 shows a plurality of density location coordinates b_{ij}. The density location generation module 26 employs a density location generation equation to generate a plurality of density location data b_{ij}. The equation is represented as:

$$b_{i,j} = O_i + \varpi(\frac{j}{n} - 1) \cdot N_i$$

where O_i represents the main position coordinates of the pen tip over time t_i; ϖ, the radius; N_i, the positive vector; n, a preset system value, used to decide the number of density locations; and b_{ij}, the j[th] density location coordinates of the i[th] main position coordinates. On the other hand, the pen stroke 14, drawn by the handwriting pen 10, comprises m main positions, and each main position corresponds to n density locations. As shown in the diagram, the main position coordinate O_i corresponds to a plurality of density location coordinates b_{ij}.

Please refer to Fig. 5. Fig. 5 shows a main line L

and density lines $l_1 \sim l_{10}$. The pen stroke generation module 28 is used to draw the main line L according to the pen tip 11 sliding across the main position coordinates O_{i-1}, O_i, and O_{i+1} over time t_{i-1}, t_i, and t_{i+1}, and to draw the density lines $l_1 \sim l_{10}$ based on the density location coordinates $b_{i-1,j}$, $b_{i,j}$, and $b_{i+1,j}$. As shown in the figure, each main position coordinate corresponds to 10 density location coordinates.

Please refer to Fig. 6. Fig. 6 is a flow diagram showing a pen stroke forming method 30 of the pen stroke generation module 28. The pen stroke generation module 28 employs the pen stroke forming method 30 to form the main line L and the related density lines $l_1 \sim l_{10}$. Suppose the main line L is formed by m main position coordinates and each main position coordinates corresponds to n density location coordinates, the example shown in Fig. 5 has m=3 and n=10.

In step 32, the pen stroke generation module 28 computes the tangent vectors, T_i and T_{i+1}, of the i^{th} and $(i+1)^{th}$ position coordinates. The equation is as follows:

$$\begin{cases} T_{i+1} = a * (P_{i+1} - P_i) \\ a \in [0,1] \end{cases} ;$$

where P_{i+1} is the $(i+1)^{th}$ position coordinate, and P_i is the i^{th} position coordinate.

In step 34, the pen stroke generation module 28 employs Blending functions to estimate the

interpolating value between the i^{th} and the $(i+1)^{th}$ position coordinates. The Blending functions are shown as follows:

$$\begin{cases} h_1(s) = 2s^3 - 3s^2 + 1 \\ h_2(s) = -2s^3 + 3s^2 \\ h_3(s) = s^3 - 2s^2 + s \\ h_4(s) = s^3 - s^2 \\ 0 \le s \le 1 \end{cases}$$

In step 36, the pen stroke generation module 28 acquires a Cardinal Splines Curve, and the equation is: $\vec{P} = \vec{P}_i * h_1 + \vec{P}_{i+1} * h_2 + \vec{T}_i * h_3 + \vec{T}_{i+1} * h_4$.

Finally, in step 38, the pen stroke generation module 28 computes the medium coordinate position between the i^{th} and the $(i+1)^{th}$ position coordinates, and links the entire coordinate positions to form a smooth curve. The equation of the medium coordinate position is:

$P = S * h * C$; where

$$S = \begin{bmatrix} s^3 \\ s^2 \\ s^1 \\ 1 \end{bmatrix} \qquad C = \begin{bmatrix} P_i \\ P_{i+1} \\ T_i \\ T_{i+1} \end{bmatrix} \qquad h = \begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}.$$

Please refer to Fig. 7. Fig. 7 is a schematic diagram showing a pen stroke formed by the pen stroke generation module 28. After the pen stroke generation module 28 employs the pen stroke forming method 30 to link all the main position coordinates into the main line, and

links all the density location coordinates into density lines, the pen stroke shown in Fig. 7 is obtained.

Moreover, the pen stroke generation module 28 consists of a variety of parameter generation modules, used for allocating various parameters for simulating different styles of pen strokes.

Please refer to Fig. 8. Fig. 8 is a block diagram of the pen stroke generation module 28. The pen stroke generation module 28 comprises a color parameters generation module 40, a speed parameters generation module 42, a speed-color parameters generation module 44, a shade parameters generation module 46, a dispersion parameters generation module 48, a pause parameters generation module 50, and a stroke-color parameters generation module 52.

The color parameters generation module 40 generates color parameters relative to the main position data and the density location data by a random number generator (not shown), for determining the color of each position at the main line L and the density lines $l_1 \sim l_{10}$. The color parameters generation module employs a color parameters generation equation to form the color parameters ρ_i. The equation is as follows:

$$\begin{cases} \rho_i = \rho_1 + \|rand()\| \% (\rho_2 - \rho_1 + 1) \\ where \\ \rho_1 \le \rho_i \le \rho_2 \\ \rho_1 ,\ \rho_2 \in [0,255] \end{cases} ;$$

where ρ_1 and ρ_2 are preset system values.

In general, the values of ρ_1 and ρ_2 are set rather closer to each other to avoid considerable difference.

The speed parameters generation module 42 generates speed parameters, relative to the main position data and the density location data, to represent the instantaneous speed of the handwriting pen 10 at each position. The speed parameters generation module 42 employs a speed parameters generation equation to generate the speed parameter V. The equation is as follows:

$$V = f(v) = \left(\frac{v_{max}^3 - 3v_{max}v^2 + 2v^3}{v_{max}^3} \right);$$

where v represents the instantaneous speed of the handwriting pen 10 at the main position coordinates, and v_{max} represents a maximum preset speed value.

During writing, due to the varying of the instantaneous speed, the ink presents a different degree of density. In general, the faster the instantaneous speed, the paler in color of the ink is. Therefore, the speed-color parameters generation module 44 generates speed-color parameters according to the color parameters and the speed parameters, for exhibiting the above relationship between the instantaneous speed and the density of the ink. The speed-color parameters generation module 44 employs a speed-color parameters generation equation to generate

the speed-color parameter $\rho_i^{'}$. The equation is as follows:

$$\rho_i^{'} = \rho_i * V$$

The shade parameters generation module 46 generates shade parameters according to the pressure value Z, relative to the main position data and the density location data. Writing or drawing with a soft pen such as a writing brush or a watercolor pen, usually makes the ink paler by the repeated depictions. Therefore, the main position data would possess a maximum value of the shade parameters, and the farther the distance from the main position coordinates, the smaller the shade parameter value of the density location data is; such that the main line *L* is the deepest, while a density line appears paler as it separates farther from the main line *L*, exhibiting a situation of shade gradient.

In general, the pressure gets lower; that is, a gentle pressing on writing, it is obvious that the shade of a pen stroke gets paler, and the shade changing is less obvious while reversely. For instance, with a harsh pressing on writing, the shade of the stroke is usually thick and homogeneous, and it is rare to be a tint. Therefore, according to the above description, the shade parameters generation module 46 generates the shade parameters based on the pressure value *Z*.

Besides, the shade parameters generation module 46 employs a shade parameters generation equation to form

shade parameter λ. The equation is as follows:

$$\lambda = (1-\lambda_0)(1-e^{-az}) + \lambda_0 \quad ;$$

where a is a user defined constant; z, the pressure value; and λ_0, a preset value of the shade parameters.

As a harsh pressing on writing, the shade of the pen stroke is especially thick and extremely homogeneous, and it is not likely to be in a tint; therefore, as the value of the pressure in the above equation exceeds a certain predefined value, the shade parameter would be a constant.

In general, the writing or drawing by a writing brush or a watercolor pen usually appears a phenomenon of being dispersed or diffused; therefore, each pen stroke exhibits a different degree in width. The longer the pen tip stays, the considerable the degree of being dispersed, and the dispersion parameters generation module 48 is used to simulate the phenomenon of dispersion.

The dispersion parameters generation module 48 generates a plurality of dispersion positions according to the main positions and the radii ϖ, for representing a plurality of dispersion position coordinates.

Please refer to Fig. 9. Fig. 9 is a schematic diagram of the dispersion position coordinates q_i. Each main position corresponds to a plurality of dispersion positions, which means that each main position

coordinates O_i corresponds to a plurality of dispersion position coordinates q_i. The dispersion parameters generation module 48 consists of a dispersion parameters D, which is used to decide the distance between every two of the dispersion position coordinates q_i, and employs a dispersion position generation equation to generate dispersion positional coordinates, such that the farther the distance from the main position coordinates O_i, the shorter the distance between the dispersion positional coordinates q_i is. The equation is as follows:

$$\frac{\partial q}{\partial t} = D\nabla^2 q \quad ;$$

where the equation is expanded by employing the finite difference method:

$$\Rightarrow \frac{q_{i+1} - q_{i-1}}{2t} = D \cdot (q_{i+1} - 2q_i + q_{i-1})$$

$$\Rightarrow q_{i+1} = q_{i-1} + 2Dt \cdot q_{i+1} - 4Dtq_i + 2Dtq_{i-1}$$

$$\Rightarrow q_{i+1} = \left(\frac{1}{1-2Dt}\right)\left(-4Dtq_i + (1+2Dt)q_{i-1}\right).$$

As in the foregoing description, the extend, beyond the radius ϖ, would confront a plurality of the dispersion position coordinates, and the distance falls between the dispersion position coordinates is gradually decreasing, and eventually approaching zero. Therefore, as a pen stroke is being formed, it tends to stretch outward, and the stretching rate would gradually decrease, eventually approaching zero. According to the different values assigned to the dispersion parameters D, the variations of the

stretching rate also vary, and further exhibiting a different degree of dispersion.

The foregoing description is about simulating the variations in position for the phenomenon of dispersion; as for the variations in color, it is available to apply it in the above equation to obtain the variations in color for the phenomenon of dispersion. Therefore, each dispersion position data mentioned above corresponds to a dispersion color data, while the dispersion parameters generation module 48 utilizes the dispersion parameters *D* too, for determining the variations in color between every two of the dispersion color data, and employs the foregoing equation to generate the dispersion color data; such that the farther the dispersion position from the main position, the smaller the variance between the dispersion color data is. Hence, it appears an effect of dispersion that the shade of color gets paler gradually.

Furthermore, the pen stroke 14 may encounter a pause, subject to the different materials of the brush pen or watercolor pen; that is, certain portions of the pen stroke 14 are vacant, and the pause parameters generation module 50 is used to simulate the phenomenon of the pauses herein.

The pause parameters generation module 50 generates pause parameters, mapping to the main position and the density locations, for determining whether the main

position and the density locations are to be seen. The pause parameters generation module 50 consists of a pause parameters preset table, possessing a plurality of the pause parameters, for corresponding to the main position data and the density location data. As a pause parameter is set to a first value, the corresponding position will be shown up; otherwise, a setting of a second value will disable the appearance of the corresponding position.

Therefore, through the pause parameters setting, certain portions of the pen stroke 14 are vacant, which makes the line an aspect of pauses. The pause parameters d can be represented as:

$d = dTable(i)$; where $d \in [0, 1]$.

If pause parameters equal 0, the actual point location of the corresponding position data is blank; otherwise, a value of 1 enables the appearance of the actual point location.

In addition to the generation of each parameter setting by the above parameters generation modules respectively, the pen stroke generation module 28 yet includes a stroke-color parameters generation module 52, and combines a couple of the above parameters to produce a stroke-color parameters.

The stroke-color parameters generation module 52 generates the stroke-color parameters according to the

color parameters ρ_i, by the color parameters generation module 40; the rate parameters V, by the rate parameters generation module 42; the shade parameters λ, by the shade parameters generation module 46; and the pause parameters d, by the pause parameters generation module 50. The stroke-color parameters generation module 52 employs a stroke-color parameters generation equation to compute the stroke-color parameters $C_{i,j}$. The equation is represented by:

$$C_{i,j} = \lambda * C_{i,j-1} * d * V \;;$$

As described in the above, the pen stroke 14, drawn by the handwriting pen 10, comprises m main position data, and each main position data corresponds to n density location data, where $C_{i,j}$ represents the stroke-color parameters to which the j^{th} density location coordinates of the i^{th} main position coordinates corresponds.

Please refer to Fig. 10. Fig. 10 is a schematic diagram of different pen strokes. By applying the handwriting pen 10 of the present invention, it is available to simulate a variety of pen strokes of which the figure shows only two kinds, and the main system 21 puts the simulated pen strokes on the connecting screen.

Please refer to Fig. 11. Fig. 11 is a schematic diagram of the handwriting pen 100 of the present invention. The handwriting pen 100 connects to the main

system (not shown) by a signal transmission line 120; for instance, a computer, and the usage of the handwriting pen 100 is associated with a handwriting tablet 140. As shown in the figure, the handwriting pen 100 comprises a pen stick 160, and a pen head 180 fixed at one end of the pen stick 160. The pen head 180 is made of soft materials, such as rubber or plastic; a common trait of them is their shapes deformed under pressure, and restoring as the pressure releases. As shown in Fig. 11, the shape of the pen head 180 imitates the geometrical outline of the brush pen, and simulates the pen stroke of the brush pen.

Please refer to Fig. 12. Fig. 12 is a system structure diagram of the handwriting pen 100. The handwriting pen 100 again comprises a gear 200, a rotational velocity detector 220, a pen tip 240, and a central stick 260. The central stick 260 comprises a first stick 280, extending from the pen stick 160 into the pen head 180; a second stick 300, locating inside the pen head 180; and a spring 320, joining the first stick 280 to the second stick 300. The spring 320 could be a torsion one or an extension one, such that the handwriting pen 100 bends under pressure, and restores at pressure diminishing.

As shown in Fig. 12, the pen tip 240 is fixed at one end of the second stick 300, extending beyond the pen head 180; and the gear 200 is fixed at the lateral of the central stick 260, located in between the first

stick 280 and the second stick 300. The rotational velocity detector 220 is fixed at the lateral of the first stick 280, and located on the top of the gear 200. The rotational velocity detector 220 detects the variation of magnetic force during the rotation of the gear 200, and computes the instantaneous velocity of rotation according to diameter and length of cog of the gear 200. The rotational velocity detector 220 can be realized by adopting Philips manufactured KMI22/1 apparatus, which not only detects the rotational velocity of gear 200, but computes its rotational direction.

Please refer to Fig. 13. Fig. 13 is a schematic diagram of the handwriting pen 100 undergoing a deformation at its pen head 180. Since the pen head 180 of the handwriting pen 100 is made of soft material, it will come across a degree of deformation, subject to the different pressing force of individuals. As shown in the figure, once the pen head 180 deforms, the spring 320 would bend under that force. Due to the spring 320 joining the first stick 280 to the second stick 300, as the spring 320 confronts a degree of bending by a variant force, the angle between the first stick 280 and the second stick 300 varies proportionally too. Besides, since the gear 200 is located between the first stick 280 and the second stick 300, the changing of the angle between the two sticks causes the gear 200 rotating a proportion, which consists of variations both in speed and direction. In other words, as the pen

head 180 deforms, the gear 200 undergoes a proportion of rotation accordingly.

Please refer to Fig. 14. Fig. 14 is a schematic diagram of the gear 200 and the rotational velocity detector 220 of the handwriting pen 100. The rotational velocity detector 220 is located on the top of the gear 200. The gear 200 has a plurality of cogs 520. As the gear 200 rotates, the rotational velocity detector 220, on the top of the gear 200, detects its rotation, and counts a rotational velocity and a rotational direction according to the diameter and the length of the cog of the gear 200.

Please refer to Fig. 15. Fig. 15 is a circuit block diagram of the handwriting pen 100. The handwriting pen 100 further comprises a pen tip position sensor 340, fixed in the pen tip 240, for sensing the position coordinates (X, Y) of the pen tip 240 on the handwriting tablet 140; and a pressure generator 360, connected to the rotational velocity detector 220, for receiving the rotational velocity data and the rotational direction data of the gear 200, and generating a pressure value Z according to the rotational velocity data and the rotational direction data. The position coordinates (X, Y) accompanying the pressure value *Z*, are transferred to the main system by the signal transmission line 120.

As shown in Fig. 15, the pressure generator 360 comprises a signal processor 380, for receiving the

rotational velocity data and the rotational direction data of the gear 200, and generating a tangential velocity of the gear 200 according to the rotational velocity data and the rotational direction data; and a pressure signal transformer 460, connected to the signal processor 380, for receiving the tangential velocity, and generating the pressure value Z according to the tangential velocity.

The signal processor 380 comprises a gear position sensor 400, a direction sensor 420, and a tangential velocity generator 440. The gear position sensor 400 is used to sense rotational position of the gear 200. As the gear position sensor 400 senses a cog 520 of the gear 200, it will signal a position. The direction sensor 420 is used to sense rotational direction of the gear 200 and to signal a direction. Once the rotational direction of the gear 200 is clockwise, the direction signal is 1; otherwise, -1 for a counterclockwise rotational direction.

The tangential velocity generator 440 connects to the position sensor 400 and the direction sensor 420, for receiving the position signal and the direction signal. The tangential velocity generator 440, employs a quotient, dividing perimeter of the gear 200 by the number of cogs to compute distance between two cogs 520; employs another quotient, dividing the distance between cogs by time interval of two position signals to compute the tangent rotational speed of the gear 200; and

applies the direction signal, determining the direction of the tangent rotational speed, and obtaining the resulting tangential velocity. The equation of calculating the tangential velocity is as follows:

$V_t = \pm 1 \times P/N_c \times 1/T_i$;

where

V_t: tangential velocity

P: perimeter of the gear

N_c: number of cogs

T_i: time interval.

As shown in Fig. 15, the pressure signal transformer 460 comprises an angle calculator 480 and an angle-pressure transformer 500. The angle calculator 480 is used to receive the tangential velocity, generated by the tangential velocity generator 440, and to compute bending angle θ_2 of the pen head 180 according to the tangential velocity; while the angle-pressure transformer 500 is connected to the angle calculator 480, used to receive the bending angle θ_2, and to generate the pressure value Z according to the bending angle θ_2.

Please refer to Fig. 16. Fig. 16 is a schematic diagram of the bending angle of the pen head 180. As shown in the above, as the pen head 180 deforms into a bend, the angle between the first stick 280 and the second stick 300 varies proportionally. In the current example, the bending angle θ_2 is defined as the angle θ in Fig.6.

To compute the bending angle θ_2 of the pen head 180 over time t+Δt, the angle calculator 480 has to have the following known parameters: r represents the length of the pen head 180; θ_1, the bending angle of the pen head 180 over time t; ∂_1, the angular acceleration of the gear 200 rotates over time t; ϖ_1, the angular velocity of the gear 200 rotates over time t; and Δt, a unit time.

The tangential velocity, received by the angle calculator, is represented by v_2, which is the tangential velocity of the gear 200 over time t+Δt. The equation of the angular velocity ϖ_2 of the gear 200 rotates over time t+Δt is:

$$\varpi_2 = \frac{v_2}{r} \quad .$$

Also, the equation of the angular acceleration ∂_2 of the gear 200 rotates over time t+Δt is:

$$\partial_2 = \frac{(\varpi_2 - \varpi_1)}{\Delta t} \quad .$$

The bending angle θ_2 is:

$$\theta_2 = \theta_1 + \varpi_1 * \Delta t + \frac{1}{2} * \partial_2 * \Delta t^2 \quad .$$

Please refer to Fig. 17. Fig. 17 is an angle-pressure variation graph showing the relationship between the bending angle θ of the pen head 180 and the pressure value Z exerting on the handwriting pen 100. The angle-pressure variation table is preset, and stored

in the angle-pressure transformer 500. The angle-pressure transformer 500 employs the preset table to generate a pressure calculation formula, and substitutes the bending angle θ_2 of the pen head 180 over time $t+\Delta t$ into the formula to compute the pressure value Z. The formula is as follows:

$$Z = \begin{cases} K_1 * \theta & ,\text{if } 0 \le \theta \le \theta_a \\ K_2 * (\theta - \theta_a) + K_1 * \theta_a & ,\text{if } \theta_a \le \theta \le \theta_b \\ K_3 * (\theta - \theta_b) + K_2 * (\theta_b - \theta_a) + K_1 * \theta_a & ,\text{if } \theta \ge \theta_b \end{cases} ;$$

where K_1, K_2, and K_3 are preset slopes, and θ_a and θ_b are preset angles.

Please refer to Fig. 18. Fig. 18 is a schematic diagram of another example of the handwriting pen 540 of the present invention. The shape of the pen head 560 of the handwriting pen 540 imitates the geometrical outline of the watercolor pen, for simulating the stroke of the watercolor pen.

As a result, the pen heads, 180 and 560, of the handwriting pens, 100 and 540, are made of soft materials, and their shapes imitate the geometrical outlines of the brush pen and watercolor pen; moreover, the handwriting pens, 100 and 540, will compute the pressing force by individuals according to deformation of the pen heads, 180 and 560, to simulate the strokes of the brush pen and the water color pen respectively.

While the present invention has been shown and described with reference to a preferred embodiment

thereof, and in terms of the illustrative drawings, it should not be considered as limited thereby. Various possible modifications, omissions, and alterations could be conceived of by one skilled in the art to the form and the content of any particular embodiment, without departing from the scope of the present invention.